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SOME PROBLEMS OF THE MANAGEMENT OF SHARED STOCKS

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

SOME PROBLEMS OF THE MANAGEMENT OF SHARED STOCKS

by

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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Abstract

The paper discusses the problems facing countries when managing stocks of fish that move between their EEZs and the EEZs of adjacent countries, or onto the high seas. The action needed depends on the pattern of movement of the stocks. The different patterns of movement are discussed; they vary from small local dispersions in which only a small proportion of the stock cross boundaries between national EEZs to long migrations in which virtually all the stock may move from one EEZ to another. Collaboration between countries in research on shared stocks is always beneficial, and should not raise any serious problem. Collaboration in choosing and implementing management measures can be more difficult. The problems raised, and the nature of collaboration required to achieve effective management are discussed in relation to the different patterns of movement.

CONTENTS

		Page
1.	INTRODUCTION	1
2.	TYPES OF FISH MOVEMENT	2
	2.1 Biological characteristics	2
	2.2 Relation to national boundaries	5
	2.2.1 Stocks located in a single EEZ	6
	2.2.2 Non-migratory shared stocks (transboundary stocks)	6
	2.2.3 Shared migratory stocks	7
3.	COOPERATION IN RESEARCH	8
	3.1 Benefits from cooperation	8
	3.2 The requirements from scientific research	9
	3.3 Arrangements for cooperation in research	10
4.	COLLABORATION IN SETTING MANAGEMENT MEASURES	12
	4.1 Problems and benefits of collaboration	12
	4.2 Non-migratory shared stocks (transboundary stocks)	13
	4.3 Regular seasonal migrations	13
	4.3.1 General requirements	13
	4.3.2 The strategic choices	14
	4.3.3 Tactical decisions - Allocation	14
	4.3.4 Implementation and enforcement	17
	4.4 Movements related to growth and development	18
	4.5 Fishing in other EEZs	19
	4.6 Administrative arrangements	19
	4.7 High seas fisheries	20
5.	REFERENCES	21

1. INTRODUCTION

The management of large-scale industrial fisheries, and the research into these fisheries has been for a century or more achieved through close international collaboration (particularly through regional fishery bodies of one kind or another). This period, which may be dated from the beginnings of trawling with steam-powered vessels in the North Sea in the last quarter of the nineteenth century is for most stocks now coming to an end as a result of the changes in the legal regime of the ocean.

The reason for international collaboration was simple; most fishing was done on the high seas, beyond the jurisdiction of any one coastal state. Once a good fishing ground was established, anyone was free to fish there, and often fishermen from several countries did so. Where there might be fishing vessels from half a dozen countries fishing on the same ground, perhaps within a mile of each other, collaboration has taken a number of forms. The first was to bring some order to the actual fishing operations, and to minimize actual physical interference between vessels by setting rules, e.g., the North Sea Convention of 1882 specifies how various types of fishing vessels should operate, for example, in stipulating that decked vessels should shoot their nets to windward of undecked vessels. International collaboration in research has almost as long a history notably in the north-east Atlantic following the establishment of the International Council for the Exploration of the Sea (ICES) in 1903 (see, for example, Went, 1972).

One reason for the establishment of ICES was the concern of several countries over the decline in catches of the more choice species in the North Sea. This was soon shown to be due in large measure to heavy fishing, and the demonstration of this by the scientists naturally led to the third form of collaboration - in the formulation and implementation of measures to conserve and manage the stocks. By the mid nineteen-seventies there were many international agreements, and formal commissions with responsibility for managing stocks in one or other specified regions of the world (see Gulland and Carroz, 1968; Cushing, 1972).

Extension of limits of jurisdiction over fisheries out to 200 miles has completely changed this situation. Though there are still wide areas of ocean beyond these limits, catches of fish in these areas account for barely 1% of the world catch. The rest is taken within the jurisdiction of one or other coastal state. The state within whose jurisdiction the fishing ground falls will have full responsibility for research, management and control of fishing operations on that ground. Vessels from other countries may be allowed to fish, but only under conditions set by the coastal state. On the face of it therefore the need for international collaboration and coordination no longer exists.

This is far from being true. Individuals of nearly all commercial types of fish (including most apparently sedentary molluscs and crustaceans) move from one location to another, if sometimes only during certain stages of their lives. Equally, most of the organisms on which they feed also move. In many cases these movements, especially of the younger stages of commercial species, or of food organisms, are a result of passive drift in the ocean current systems. Many of these movements take place across the new marine boundaries between national jurisdictions. Thus events in one area can affect what happens in another, and it may easily happen that the attempts by one country to manage the fishery in its area of jurisdiction can be nullified by uncontrolled exploitation on the same stock in some other area of jurisdiction.

Some form of international collaboration will therefore often be desirable, and sometimes be essential. However, the nature of such collaboration, which involves actions taken by countries in areas where they claim jurisdiction rather than on the high seas, is not at present clear. This doubt can have at least two kinds of ill effects. The first has already been noted - in the absence of adequate collaboration there are a number of fish stocks where effective measures cannot be taken by individual countries acting in isolation. Conversely, there are other fish stocks which, because of the restricted nature

of the displacements of the individual fish or their schools, can be managed by an individual country without reference to actions of others. The latter group includes several for which management measures are urgently required, but for which action has been inhibited by uncertainties about what pattern of international collaboration, if any, is needed.

The need for collaboration has been recognized by those participating in the U.N. Conference on the Law of the Sea. In addition to special provision for so-called "highly migratory species" (Article 64), the draft text calls upon states "to seek either directly or through appropriate sub-regional or regional organizations to agree upon the measures necessary to coordinate and ensure the conservation and development of such stocks (which occur within the exclusive economic zone of two or more states)" (Article 63). However, the text does not discuss the nature of such coordination, or the degree to which it may depend on the biology and behaviour of the stocks.

This paper is intended as part of continuing studies by FAO to assist in consideration of these issues. It discusses general issues, including the different patterns of movement and behaviour of fish stocks, the types of coordination that are needed, the factors that might be taken into account in taking any joint action, and the information requirements. Later papers are planned to provide brief over-views, region by region, of the main stocks that occur in two or more areas of national jurisdiction. These studies will not be concerned with suggesting specific actions, but only with pointing out where there appears to be needs for such action.

2. TYPES OF FISH MOVEMENT

2.1 Biological characteristics

Species or stocks of fish can be classified in several ways according to the nature of their movements, and to how their movements relate to the boundaries between national EEZs, and between EEZs and the high sea areas.

Although they are not virtually exclusive, three basic types of movements during the life of an individual fish can be usefully distinguished:

(1) Regular seasonal migrations

(2) Regular movements in accordance with the growth and development of the fish

(3) Random movements or dispersions

A further type of movement should also be borne in mind. This is the possible medium to long-term changes in the general location of the stock. As more series of data of individual stocks over long periods become available it is clear that the geographical position of a stock is not fixed. Sometimes the change can be easily related to changes in climate, e.g., a general warming may allow a stock to extend its distribution further towards the poles (the impact of climatic changes has been reviewed by Cushing and Dickson, 1976). Other changes, e.g., alteration in the dominant clupeoid species in the English Channel between herring and pilchard, may be more subtle. An important case is where a reduction in the population abundance is accompanied by a shrinking in its area of distribution. The California sardine, which at its peak was found as far north as southern British Columbia (Murphy, 1966) is a good example. In any case, though the changes may be easy or difficult to explain they are almost impossible to predict. The practical point is that the pattern in which a stock is shared between countries (or indeed whether or not it is shared at all) is not fixed, but can change over the years. For example, until recently the sardines off north-west Africa were confined to Morocco, but has now extended their distribution southward so that at least the more southerly stock is shared between Morocco and Mauritania.

This type of change in distribution is not considered further here, but must be borne in mind in setting up arrangements to deal with shared stocks.

The term migration has been used in many ways; a representative dictionary definition (Concise Oxford Dictionary) is "(of birds and fishes), come and go with the seasons". This generally implies a systematic shift in the main concentrations of fish, often to the extent that there is little or no overlap between where the fish are in summer and in winter. The best known examples are of birds, both because they are easily seen and because they can move faster and further - the record being held by the Arctic terns that migrate between the Arctic and Antarctic. In the sea the movements of whales between the Antarctic, where they feed, and the warm tropical and sub-tropical waters, where they breed, provide good examples of clearly defined migration.

Another, if somewhat extreme example of long migrations, in this sense, as well as of the seasonal type of movements (those associated with the growth and development of the individual fish) is provided by the Atlantic bluefin tuna. This spawns in tropical areas, the juveniles grow up in sub-tropical and temperate waters, and the adults perform long-distance migrations, moving to summer feeding areas as far north as Norway and Newfoundland, returning to spawn in the Caribbean and the Mediterranean.

Migrations require energy to perform. There must therefore be significant advantages in terms of, e.g., food supply, overall survival or recruitment success, to make the movements worthwhile. This probably implies marked seasonal changes in the food supply or other conditions in at least part of the migration path (though the movements of the fish might well be such as to keep itself in some preferred, and reasonably constant, conditions).

One might therefore expect that migrations would be longer and more marked where the seasonal differences are greatest, i.e., in temperate rather than in tropical or sub-tropical waters. One might further expect that the seasonal migrations would be predominantly north and south. To some extent this is true, e.g., the sardinella off north-west Africa move up and down the coast between southern Mauritania and Guinea-Bissau, but there are several other patterns of movement, among which inshore-offshore patterns are particularly common. In temperate regions the inshore waters can be highly productive in summer, and fish go there to feed, but are cold and unattractive in winter, and the fish retreat to deeper water. In the Indian Ocean the monsoon winds can in some places and seasons cause the bottom waters to become deficient in oxygen, so that the demersal fish move, either well offshore, or to very shallow waters close inshore. Other seasonal changes, e.g., in the depth of the thermocline, can cause similar inshore-offshore migrations.

Movements in accordance with the growth and development of the individual fish are at least as important as the seasonal migrations. Fish pass through a number of life-stages that are extremely different in their nature and requirements. In the first few months of life, as eggs and small larvae, most marine fish generally drift somewhat passively with the prevailing currents; the larvae of many species then settle in a nursery area (often in shallow coastal waters) until they reach a size at which they join the main adult fish stocks. For species with pelagic eggs or larvae this pattern must involve some active directed movement to counter-balance the drift in the larval stage (for example, adult cod move from the Spitzbergen/Barents Sea shelf to the spawning area round the Lofoten Islands, and the eggs and larvae drift back north in the extension of the Gulf Stream), but there may be more complicated patterns of movement.

All types of fish (including crustaceans and molluscs, other than those firmly attached to the bottom) make movements of the third type. The differences between species or stocks lie in the distances covered, and the degree to which the individual fish has some type of home territory, to which it will tend to return, or whether any directed movements tend merely to maintain the fish in favourable environmental conditions, irrespective of the precise geographical location.

The extent of the movements range from the scallops which may make no more than an occasional jump of less than a metre, to the tunas, whose continual active swimming may take them a hundred kilometres away from their starting point in a day or so. Compared with the knowledge of terrestial animals, little is known about the territorial habits of most fish. One might expect it to be better developed for fish living in close contact with permanent features such as are provided by rocky bottoms or coral reefs than for fish living in the open sea. However, even for these the sea is less featureless than might appear from a ship, so that the extent of their movements may be smaller than that of suitable conditions. The implication is that if, for example, a species is distributed continually along an extensive coast, the movements of any individual fish may well cover much less than the whole extent.

So far as management policies and the needs for collaboration between countries are concerned, the several patterns of movement can have important differences. In the simplest form of the second pattern each fish will, apart from the return of adult fish to the spawning grounds to complete the cycle, move through each area (nursery grounds, feeding area, spawning area) once, and only once, during its life. The fisheries in different areas interact in a clearly hierarchical manner. Fishing in any one area will (so far as a given brood of fish is concerned) only be affected by fishing "up stream" (i.e., on younger fish), and only affect those "downstream" on older fish. Interactions will be effective in the opposite direction (i.e., fisheries on older fish will affect those on younger fish) only to the extent that recruitment is affected by the abundance of adult fish. This is not always apparent, and (which is perhaps more significant in terms of getting agreement) is in virtually all cases difficult to demonstrate, at least until the recruitment has been seriously reduced. Nevertheless, prudent management of any stock should involve the maintenance of the minimum abundance of spawning fish, whether or not a relation with recruitment has been clearly demonstrated.

In contrast, seasonal migrations in their simplest form, for relatively long-lived fish, result in a more balanced type of interaction. Fishing on the wintering grounds may affect the summer fishery in the subsequent year, but they in turn will be affected by summer fishing in previous years. The incentives for an agreement for coordinated management of the resources are therefore greater here than in the other pattern, in which the country whose fisheries act "upstream" of the others may be less immediately inclined to seek agreement.

The impacts of the third type of movement - random, or at least a poorly defined dispersion - are less easy to describe simply. Where the movements are large compared with the distribution of the species or stock, then the movements achieve a good mixing within the species or stock. This means that a given level of removals by one group of fishermen will have an equal effect on all fishermen, wherever and whenever, within the distribution of that stock, the fishing is carried out. On the other hand, if the movements are small compared with the range of the species, then there will be little or no interaction between fisheries at the opposite extremes of the range, even though between them there is no barrier or point at which one can say there is a separation between stocks. For example, many species of demersal fish occur off the coasts of all the countries in the Gulf of Guinea, and move back and forth along the coasts (Champagnat and Domain, 1978). The distances covered in these movements are not well known, except for a few species and locations where tagging experiments have been done, but probably average not more than a hundred miles. This means that many fish will move between say western Ghana and eastern Ivory Coast, but not many across the whole width of the two countries, between eastern Ghana and western Ivory Coast.

The distinction between ordered migration and dispersion is not sharp. There are likely to be variations in the timing, distances and directions of migration between individuals so that an initially compact group of fish will become dispersed over a wide area. For example, in the Pacific skipjack tuna exhibit some clear patterns, e.g., as exhibited by the results of the tagging programmes of the Inter-American Tropical Tuna Commission and

the South Pacific Commission, but some individual fish may move to quite different areas than the main bulk of fish tagged at the same time and place.

This pattern of dispersion raises problems in the definition and interpretation of the term 'stock'. This term, unlike related terms such as 'species' or 'population', which have reasonably clear biological definitions, has a practical and operational basis related to the particular problem being faced - a 'unit stock' (or 'stock') is a group of fish that can or has to be treated as a 'unit stock' for some definite purpose. That is, there is no objective definition, valid under all circumstances, of what is meant by a unit stock - certainly no real definition will be attempted here. Rather, a unit stock is an empirical grouping of fish that is sufficiently large that, when analysing the data concerning it, or taking policy decisions about its exploitation and management, events on adjacent 'stocks' can be ignored, or at least treated in a different way to events within the stock. Equally, it should be sufficiently small to be for practical purposes homogeneous, and for possible divisions within the stock, into smaller groupings, to be ignored.

It should be clear from this that what is considered a stock is not an absolute, but can change, depending on the purposes, for convenience of analysis or policy making. Also there can be situations when there is no group of fish that can satisfy the conflicting requirements described in the previous paragraph. In these situations, the methods of analysis and approaches to policy making will have to be modified - usually in the direction of being more complicated and difficult to apply - to take account of the biological realities and particular conditions of the fisheries.

For some fish the concept of unit stocks works well. For example, the fact that individual Pacific salmon returns to spawn in the stream in which they were born means that the fish spawning in particular streams can be used as the basic bricks, to be taken together in larger or smaller groups to form stocks for different purposes. In international discussions between Japan on one side, and the U.S.A. and Canada on the other, it may be sufficient to treat salmon spawning in Asia and in North America as two stocks. Between the U.S.A. and Canada, stocks may be considered as groups of fish originating in each major river system, but at the national level, when applying detailed management measures, the separation of stocks may be taken down much finer, possibly to the individual stream.

The same may be true for other species which have a well-defined homing instinct (which may be few) and the more numerous species which have distinct and well-separated spawning areas, even when it is not clear that all fish return to spawn in their original areas. For example, the herring spawning in the Downs, at the southern extremity of the North Sea, form a distinct group, which mixes with the 'Bank' group, spawning further north, on the summer feeding grounds in the central and northern North Sea. Neither group seems to mix much with the herring spawning outside the North Sea. For different purposes the Downs herring, or all North Sea herring, can be treated as unit stocks.

For species with dispersed spawning, possibly throughout its range, the situation is much less clear. For skipjack in the Pacific, or croaker off West Africa, there does not appear any distinct groupings. For these species there may be for many purposes no group that can be treated as a simple unit stock. Rather there may be a group of fish or fishermen of primary interest, and other groups at increasing distances which will be of decreasing relevance. For example, in considering the croaker fishery of Ghana, considerable account should be taken of what is happening off Togo or eastern Ivory Coast, but very little about the fishery off Cameroon or Sierra Leone. Similarly anyone analysing the skipjack fishery of Papua New Guinea or considering its management needs to take great account of events in the Solomons, and probably some note of those around the Carolines or New Hebrides, but can ignore anything happening off South America.

2.2 Relation to national boundaries

Species and stocks of fish can also be classified according to the relation of their

movements to national boundaries. This clearly depends as much on the pattern of the boundaries, as on that of the movements - long movements may still lie wholly within a large nation's EEZ, while elsewhere a short movement may be enough to cross a boundary between one EEZ and another. The classification of stocks in relation to boundaries will therefore be somewhat different to that based on purely biological considerations. A possible classification is as follows:

(1) Stocks lying wholly within a single national jurisdiction.

(2) Stocks occurring within two or more EEZs, with movement across boundaries, but no clear migratory pattern.

(3) Stocks occurring within two or more EEZs, and a clear pattern of movement (seasonal migration or movement according to developmental stages) between one zone and another.

(4) Stocks occurring wholly on the high seas beyond national jurisdiction.

(5) Stocks occurring both on the high seas and in one or more national jurisdiction.

These categories are not absolute, and groupings and sub-divisions can readily be suggested. For example, group (5) might be divided, in the same manner as groups (2) and (3) are distinguished, between stocks with clear migrations, either seasonal or according to developmental stages (e.g., southern bluefin tuna, with its spawning grounds in the southeast part of the tropical Indian Ocean; nursery grounds in the coastal waters off Australia; and feeding area in the temperate oceanic waters from southern Africa to New Zealand), and those whose movements, so far as they are known, are in the nature of random dispersal (possibly skipjack). However, the present grouping is convenient; some characteristics of each group are discussed below.

2.2.1 Stocks located in a single EEZ

From the point of view of this report these are the least interesting stocks. The study and management of these stocks is purely a matter for the state in whose waters the stock occurs. Nevertheless, it must be recognized that this group is extremely heterogeneous. It contains many small resident stocks, but also many stocks whose movements are by no means negligible but happen to be less extensive than the national limits (e.g., most fish stocks off Australia, haddock around Iceland, etc.). It should also not be assumed that a stock necessarily falls into this group merely because present catches are limited to a single national EEZ. Many of the species, especially molluscs and crustaceans, which are partially or wholly sedentary in the exploited phase are mobile at early stages of their life history, even if it is a matter of drifting in the currents. The success of a fishery for scallops or lobster may therefore depend on the conditions on spawning grounds some distance "up-stream", including the abundance of spawners, and be affected by the amount of fishing on those grounds. In such cases the stocks concerned should be more properly considered in group (3).

2.2.2 Non-migratory shared stocks (transboundary stocks)

Some movement across boundaries is certain to occur except when the boundary coincides with a natural barrier. For example, between island states, or between countries facing each other across straits, there is often deep water that is an effective barrier to many adult fish, especially bottom-living species. In such cases the fish round each island may form separate stocks. On the other hand, if two countries lie adjacent to each other along the edge of the continent, and the same species occurs in both countries, then it can be taken as virtually certain that there is some interchange across the boundary, even in the absence of any systematic migratory movement.

This does not mean that the two countries share a single stock. Because of their lack of systematic movement many of the species falling in this category are likely to

form a number of stocks. Often there are no well-defined distinction between one 'stock', e.g., in one bay, and the next. Many inshore species of fish and crustaceans will fall into this category. For example, throughout the whole of south and southeast Asia, the small-scale fishermen exploit very much the same group of species, the differences between one district and another being mainly of a matter of local ecological conditions (nature of the bottom, etc.). Across most boundaries of national EEZs, e.g., between Thailand and Malaysia, or India and Bangladesh, there will be interchange, but the fish concerned will probably not move far. Thus the effects of events on one side of the boundary are not likely to extend more than perhaps a few kilometers into the adjoining EEZ. It is perhaps useful to use a distinct term for this category of stocks; the term 'transboundary stock' is suggested. A feature of these stocks is that the relations tend to be symmetrical, i.e., conditions tend to be similar either side of the boundary, and movements of fish across the boundary in one direction are likely to be about equal to movements of fish, in similar numbers and of similar sizes, across the boundary in the opposite direction. An exact balance of movements across the boundary will depend on the fisheries on each side being similar, as well as the fish. This will often be the case, but sometimes there may be an abrupt change in social or economic factors between adjacent countries sharing a marine boundary. This may give rise to differences in fishing methods and/or intensity, and hence a net flow of fish from the lightly fished area into the more heavily fished. This general and biological symmetry may be contrasted with the lack of symmetry that often occurs in the following category.

2.2.3 Shared migratory stocks

This category includes a large number of stocks, possibly even the majority of the stocks supporting large-scale industrial fisheries. Within this large group the details vary greatly, particularly in regard to the proportion of the total stock that moves across the boundary, and the extent of the differences in the composition or behaviour of the stock on either side of the boundary.

The ordered movements of this category imply almost inevitably some differences in conditions at either end of the migration path. Hence the effects of fishing on the stock at one place rather than another, and the benefits that can be gained from such fisheries, are not likely to be equal. This is clearly the case for movements associated with growth and development of the fish - from nursery area, to adult feeding area, to spawning ground. The literature on the dynamics and management of fish stocks is full of studies showing the effects of varying the ages at which fish are caught. These show that there is a loss in the yield by catching fish before the growth rates begins to slow and to be balanced by losses due to natural mortality. This is likely to cause problems when the nursery grounds lie in one EEZ and the adult stock in another. For example, in the northeast Atlantic part of the nursery areas of the stock of cod spawning at the Lofoten Islands in northern Norway lie in the EEZ of the Soviet Union (Dannevig, 1954; Maslov, 1944). Though older fish also occur in this zone the catches there tend to be of fish smaller than the optimum size at first capture. Again Champagnat and Domain (1978) have shown that along the West African coast from Mauritania to Guinea several of the demersal species have distinct areas of distribution of adults and juveniles, often in different countries.

Some distinction between the areas inhabited by different stages in the life history exists in nearly all fish. Very often the main difference is that the younger stages are found inshore in shallow water (often brackish waters). The movements from the nursery or juvenile grounds to those inhabited by the adults thus tends to be right angles to the coast. They are therefore generally parallel to the boundaries between natural EEZs, rather than across them. On the other hand, river estuaries are important nursery areas for many species, and are also frequently the boundaries between states. This increases the likelihood that movement offshore from the nursery grounds will take the fish across the boundary between national EEZs. On the whole, the impact of this type of movement on the degree of interaction between fisheries in different EEZs is somewhat less than its frequency might suggest, but it certainly is significant for some stocks. For example,

when the shrimp stock that has its nursery grounds in the Casamance area of Senegal moves offshore to the adult grounds it enters the EEZ of Guinea-Bissau. Often this has the same effect as some degree of random dispersal; that is, if both inshore nursery areas and offshore adult grounds occur in an EEZ of two adjacent coastal states, it cannot be expected that, in their movement offshore, the fish will remain precisely in their original EEZ, but that there will be some mixture.

Seasonal movements of adult fish ("migration" in the stricter sense) is somewhat less general, being more common in temperate waters than in tropical waters with less marked seasonal changes. Movements are often north and south, tending to keep in somewhat similar conditions, e.g., of water temperature, and are commonly parallel to the coast. A higher proportion of the stocks moving in this way will therefore cross national boundaries. For example, off northwest Africa most of the important pelagic species (sardinella, mackerel, etc.) move across two or three EEZs during the year. During these movements there can be big changes in the behaviour and condition of the fish. They may disperse during the feeding season, and then congregate in dense - and easily caught - schools just before and during spawning. At the end of the feeding season they will be fat, in good condition and likely to fetch a high price, while after spawning they may be thin and worth little. Thus the attractions for the fishermen will not be the same in all parts of the range; in the extreme it may only be worth fishing at certain times and places. For example, in the northeast Atlantic there is a large stock of blue whiting to the west and north of the British Isles. During the feeding season it moves north and occurs widely in the EEZs of Norway and the Faroe Islands, but at this time the fish are so dispersed that the catch rates are not high enough to support an economic fishery. During the spawning season the fish move south into the British EEZ, and form concentrations that can support fisheries for both consumption and meal.

3. COOPERATION IN RESEARCH

3.1 Benefits from cooperation

When a stock of fish moves between the EEZ of more than one country it is clearly desirable that these countries cooperate in the research, management and rational exploitation of that resource. At the same time, there can be problems in achieving that cooperation; it can introduce another layer of administrative machinery into an overloaded system; meetings and travel between countries is expensive, and in particular some countries may be unwilling, in the period after the introduction of EEZs, to take action which might appear as sharing authority over the fisheries in their EEZ.

Cooperation is therefore discussed here in two parts: first in respect of the scientific study of the stocks, and the second in respect of the actual application of management measures. Only the second raises problems of authority. Countries are free to take whatever action they think appropriate in the light of their national objectives, and the scientific evidence. The better the science, the more likely it will be that the action taken will achieve the desired objectives.

The main benefit from international cooperation in research is that it becomes possible to consider all the information concerning a stock of fish, wherever it occurs. In the absence of such information it is very easy for a country to misinterpret what is happening to the stocks in its EEZ, even when it has good information on everything that is happening in that zone. For example, a small increase in national fishing effort could coincide with a large decline in catch rate due to a large increase in fishing on the same stock elsewhere. This might be interpreted as too heavy fishing of a small stock, and lead to the introduction of severe control measures, if the events in the other areas were not taken into account. This is perhaps an extreme example, and in practice scientists in one country should be aware of such gross changes in an adjoining country without the need for formal cooperation. However, there are many more subtle biological events, e.g., changes in migration pattern, which can affect national assessments, but which can easily be overlooked - or if known, cannot be taken fully into account - unless there is close

cooperation between all countries in which a stock occurs, or in whose zones events occur that can affect that stock.

Ensuring that cooperation does cover all the countries involved is not necessarily straightforward. As noted in the previous section, the concept of "stock" is not a precise one, and it can be far from clear which countries should be included in considering a group of fish in a particular area - if Papua New Guinea is interested in knowing about the stock of skipjack around its coasts it will need information from the Solomons, but it is not clear whether it will need to have information from the Philippines or from Hawaii. Consideration of the interactions between species make the definition of boundaries and the determination of which countries need to collaborate even more difficult. For example, in some years bluefin tuna have been significant predators on North Sea fish such as herring and a complete understanding of the factors affecting the North Sea herring stocks should include information on the exploitation of the bluefin tuna when they are outside the North Sea, i.e., in the Bay of Biscay or Mediterranean. In practice such a wide scope would lead to an impossible mass of detail and a narrower viewpoint has to be taken. The area covered by any particular cooperative study, and the subjects considered within that area (e.g., one particular species, all species taken by a particular type of gear, or all species that might interact with some target species of primary interest) will therefore have to be chosen in the light of the particular problems being tackled.

3.2 The requirements from scientific research

This then raises the question of the nature of the scientific advice, and the types of scientific study that have to be carried out if those taking decisions on the management and exploitation of the resources are to be properly advised. This has been reviewed several times (e.g., ICES, 1977; ACMRR, 1974, 1980), and need not be discussed again here. What needs to be stressed is that advice is not simply a matter of calculating a quantity (Total Allowable Catch) that should be taken. Account has to be taken on the one hand of the existence of varied social and economic objectives, and on the other of the complexities of the natural ecosystem.

Social and economic realities need not mean - indeed should not mean - that biologists have to attempt to include economic and other factors in their analyses. It does mean that their advice must be given in sufficient detail that economists or others can determine the economic or other consequences of different actions. In these determinations, matters such as the cost of fishing (as influenced by catch rates, and the abundance of the stock) and the seasonal and spatial distribution of the catches can be as significant as the magnitude of the total catch. The results of the scientific analyses have therefore to be presented in sufficient detail that these characteristics of the fishery, and the effects on them of different management actions are available directly, or can be deduced by economic or social analyses. These last would normally be carried out nationally rather than as part of an international cooperative biological study.

Relevant biological complexities that need to be taken into account in the scientific advice include interactions between species, and natural variations. The fact that the interactions between species greatly widen the geographic area (and hence the number of countries) that might have to be taken into account has already been mentioned. At the present state of scientific knowledge and ability to control fishing some of these extensions are only of theoretical interest. For example, it would be difficult to produce an estimate of the impact on North Sea herring stocks resulting from different patterns of fishing on bluefin tuna and unrealistic to expect that management measures for tuna in the Mediterranean would be modified in order to accelerate the rebuilding of the depleted North Sea herring stocks.

With more restricted areas the interactions are more significant and more likely to be taken into account. Although the existence of interactions between species is well-known, and the need to take account of interactions often acknowledged (FAO, 1978; May et al., 1979), very little is known about the quantitative nature of the interactions between species, and the likely magnitude of some of the important factors (e.g., the amount of food consumed by an individual fish). To build models of how multi-species systems will behave under different

patterns of exploitation is heavily dependent upon knowledge about specific sets of food web and energetic processes. In some cases these seem to be approaching sufficiently close to reality to be useful in determining the direction of the effects of management actions, e.g., increased fishing on anchovy will cause some reduction in the growth of predatory fishes. The models and the information used in them however are not yet sufficiently accurate to give reliable quantitative answers, e.g., by how much will the growth of predatory fish (and the catches of these fish) be decreased by a given increase in fishing on anchovy.

The impact of natural variations, e.g., in ocean currents, on fisheries can be of several different kinds. Many fish stocks exhibit great fluctuations in abundance either from year to year or over longer periods. Of particular interest in the present context are changes in distribution. These changes can alter the proportion of a stock that occurs in the EEZ of a particular country, or the degree to which the fisheries in one country are affected by events in other EEZs. For example, the sardine stock off northwest Africa has been extending the limits of its distribution southward so that a stock that was once almost solely of interest to Morocco is now shared to a large extent with its neighbours. Again, the establishment of a cod stock off southern Greenland following the warming of the water in the nineteen thirties has meant that since then a significant proportion of the cod spawning off southwest Iceland have spent the early part of their lives in Greenland waters.

A further complexity in providing scientific advice, which is a direct consequence of the establishment of EEZ, is that much more is now required to be known about the distribution, migration and stock structures of the fish. The discussions in this paper make it clear that the nature of the "shared stock" problem depends on the pattern of movements, and examples are given of the various situations. What is not made clear is that for many, and indeed probably most, fish species throughout the world information on migration, distribution and stock structures is scanty or entirely lacking. Much more information on these subjects is needed to enable countries to determine how they need to collaborate in managing their resources.

All these factors - more details from which economic analyses can be made, greater account of interactions between species, and more detail on distribution and migrations - will add to the work of the scientists. This increases the importance of the other benefit from close cooperation between countries, which is that it increases the effectiveness of the scientific research, and can enable a 'critical mass' of expertise to be brought to bear on these difficult problems.

3.3 Arrangements for cooperation in research

Cooperation in research has always been one of the main functions of the numerous regional fishery bodies, both within and outside the structure of FAO. The structure and methods of operation of these bodies need not be reviewed here, but a few points should be made.

First is the matter of timing. Governments traditionally take action only when it is clear beyond any argument that action is needed. It may be expected therefore that action to establish cooperative research programmes will often be taken only after it is clear that they cannot manage their fisheries without this. On the other hand, experience has shown that it takes time for a group of scientists to get used to working together, and to establish effective cooperative programmes, and that it takes a further period - usually of several years - before the results of these programmes can be analysed and made available to policy makers. To take an obvious example, a tagging experiment to determine migration routes involves, as one part, a minimum period to allow the tagged fish to move from one area to another, which for long-lived fish may be several years. Some of the most interesting recaptures of southern bluefin tuna tagged as juveniles off Australia are only now occurring in the Japanese long-line fishery, some fifteen years after the initial tagging. Therefore, in the cases where arrangements for cooperation in research do not already exist, urgent action is needed to establish them.

A second point concerns the structure of the arrangements, and the responsibilities of the secretariat, if any. The most extensive experience of regional collaboration has been between developed countries, notably ICES in the north-east Atlantic. In these regions the countries concerned have, in aggregate, good expertise, and the essential responsibilities of the secretariat are routine matters such as providing meeting facilities, production of reports, etc., and restricted technical work such as the compilation of statistics reported by national institutions.

The extent of the work involved in data compilation can be quite large. At the minimum it may involve no more than storing and reproducing national statistics. The scientists will soon require more, e.g., summaries of total catches, irrespective of country of capture, usually broken down by categories such as area, gear, or size or age of fish. This requires processing of data, and probably also work with national institutions to achieve the necessary standards in the data reports. Ultimately it may be that the scientific work will benefit from the establishment of an advanced data centre, with large capacities in handling and processing data. How far the central secretariat need advance in relation to particular stocks will depend on the requirements of the scientists, and also the composition of national institutions. In developing areas the immediate requirements may be relatively small, but the work may benefit from the availability to national scientists of better facilities than they have elsewhere.

Where some or all of the countries concerned are developing countries, it cannot be presumed that they will command sufficient expertise, and the secretariat may have to provide considerable professional input. At the same time when decisions about shared stocks (and especially about possible allocation of catches from these stocks) are being taken countries will be most unlikely to rely on advice in which their own national scientists did not take a part. Activities of a scientific secretariat, however well-qualified and independent can complement but not replace the work of national scientists.

In such cases the most useful function of the secretariat may be to help provide the scientific leadership that might otherwise not be forthcoming (the parallel with the possible provision of advanced data handling facilities is obvious).

Professional and technical input from the secretariat is likely to be necessary where there are scientific problems of interpretation, and where these differences are likely to have practical implications, i.e., one interpretation is favourable to the perceived national interests of one country, and another favours a different country. Fish stocks are difficult to study. The information normally available, from surveys, biological studies or records of commercial catches, gives at best indirect information on how many fish are actually present, and how many can be caught to maintain the stock in some desired condition. The draft text for the new Law of the Sea Convention calls on coastal states to take account of the "best scientific evidence available to it" in setting management measures but, because of these scientific difficulties, it cannot be expected that this evidence will necessarily point unequivocally towards a particular action as being the 'right' action to achieve some special objective. Much will depend on the interpretation of this evidence by the scientists concerned. Inevitably this must be to a greater or lesser extent subjective. Almost equally inevitably different scientists will have different interpretations, and further, these interpretations can consciously or unconsciously be biased towards the interests of the country or other groups to which the individual scientist belongs. Differences of interests between groups, and real or suspected tendencies for interpretations to be biased in one direction or another have been one obstacle to reaching 'agreed' scientific advice in respect of whales in recent years. Similar difficulties can easily be imagined for shared stocks. For example, if a stock can be harvested as juveniles in one EEZ, and as adults in another, the location at which the harvest should be taken in order to maximize the weight caught (assuming this to be the preferred objective) will depend, possibly critically, on the value of the natural mortality rate. This is always difficult to measure, and it would not be unreasonable for scientists from the first country to favour a high estimate (which would imply benefits

from harvesting juveniles), and those from the second country to favour a low natural mortality (implying that it will be profitable to wait for the fish to grow).

In these circumstances, the value of neutral scientists is great. This not so much that they should attempt to provide a single "correct" estimate, but that they can help spell out where the differences of interpretation lie, and the consequences of one or other interpretations. It would then be a matter of the administration in each country, jointly or individually, to decide what action to take in the light of this evidence.

4. COLLABORATION IN SETTING MANAGEMENT MEASURES

4.1 Problems and benefits of collaboration

Most countries are willing to collaborate in research, since there are no serious disadvantages to set against the undoubted advantages. This is not the case for collaboration in setting management measures, either in the narrow sense of determining catch quotas, size limits, etc., or in the broader sense of setting general fishing policy, including the development of fisheries. The disadvantages of losing some degree of authority over resources which, with the establishment of EEZs, are felt to have come fully under national control, are obvious, while it is not always immediately clear what benefits a country will gain from collaboration. Indeed there are some few special circumstances in which an individual country may stand to gain very little from collaboration. These are probably exceptional, and in general there can be very great benefits, as discussed in the following sections, depending on the pattern of movement of the fish, and the state of the fisheries in the various EEZs. The chances of serious disadvantages, whether real or apparent, increase as the form of collaboration changes from discussions of the problems of management (including a review of the strengths and weaknesses of different actions), through informal agreements on the general action that will be taken by individual countries, to formal and binding agreements (either through bilateral negotiations, or through the mechanisms of some international fishery commission or similar body) on specific action to be taken. Countries can find it easy to engage in discussions, even up to the point of reaching non-binding agreements on what needs to be done, when they may not find it acceptable to consider entering into binding agreements except when the damage that would be done to their fisheries by doing otherwise is both great and obvious (the two are not the same). Fortunately the way in which stocks are shared is such that formal and binding agreements on management measures are not always necessary. The reasons for this will be discussed in the following sections. In brief, the activities of each country are, to a large extent, confined to its own EEZ, so that, except when the mixing of fish between EEZs is very rapid, the damage to the fisheries as a whole which will arise if it fails to comply with an agreement will usually be felt mainly by its own fishermen. This may be contrasted with the fully open-access situation, either of a group of countries in the pre-EEZ period, or of national fishermen, where the individual country or fisherman will nearly always benefit from failing to comply with a regulation, regardless of the damage to the fishery as a whole.

In the rest of this section, which reviews the benefits which can come under different circumstances from collaboration in setting management measures, a distinction will therefore be made between situations where the benefits will only happen if the countries take fully coordinated action, and those where a country can gain benefit from unilateral action, even if the other countries do not. Put another way, there are situations where the only international collaboration that is essential is to have the technical (biological, economic and social) discussions to identify what can be done to benefit the fisheries; the rest can be left to individual countries. There are other situations where the collaboration has to include binding agreements to implement specific actions, and, what is too often neglected, arrangements to ensure that these agreements are followed by each country, and that all the other countries and their fishermen can see that they are being followed.

4.2 Non-migratory shared stocks (transboundary stocks)

Fisheries on stocks of this type may be divided into two groups - those in which the countries concerned have similar economies and those in which the social and economic conditions differ, or the countries do not have similar objectives in managing the fisheries.

The first case is the simplest that can arise when stocks are shared. If the countries have similar economies and similar ultimate objectives (concerning, say, the relative importance given to improving economic efficiency and increasing the total supply of fish), then they will probably have similar strategic and tactical objectives as to what is the desirable state in which to maintain the fish stock, and how best to attain that state. The problems of managing the fisheries on such a stock are the technical ones of determining what actions are in fact needed to attain the desired objectives. For this, international discussions will clearly be helpful. The value of biological collaboration has already been pointed out in the previous section, and is widely acknowledged, but there is equal value in discussions by all countries (at the administrative, but more particularly, at the technical level) of the other (e.g., economic and social/technical) problems. Once suitable actions have been identified, then it will be to the individual advantage of each country to implement them individually regardless of what other countries do. No formal collaboration between countries in addition to that concerned with biological studies and data exchange is necessary, and most of the disadvantages that can arise will be avoided. However, it does happen that the fact of there having been international discussions, and that an international body has made some proposals or recommendations (even if not formally binding) can put some pressure on countries to act.

If there are differences in interests, e.g., one country has a greater need for a large supply of fish, or a larger supply of labour without alternative occupations, or the other needs a higher catch rate to be attractive to its fishermen, this will result in the preferred degrees of exploitation (as measured by, e.g., the fishing mortality) being higher in one country than another. Suppose each country then manages its fishery so as to exert what is, for that country, the optimum fishing pattern. Suppose also the mixing rate is moderately slow. Then, except for places close to the boundary between EEZs, the stock abundance will correspond to the pattern preferred by the country concerned, and each group of national fishermen will be happy. At higher mixing rates, or near the border, the stock abundances will be affected by the other fishery. That is, in the EEZs of the country applying the more restrictive policy, abundance (and hence catches) will be lower than expected; in the other EEZ, catches will be above expectations. In these circumstances it is difficult to see what coordinated actions, at least terms of applying a unified policy, would be attractive to both countries. The more restrictive country might hope to encourage the other to reduce its fishing, but can offer it little incentive to change a system which clearly suits it - why should it be asked to fish less, still less why should it encourage the first country to fish harder.

This is not to say that in practice there will not be advantages to the countries in discussing the management of these shared stocks. Often the difference in interest may be more apparent than real. It can easily happen that a full analysis of the potential benefits of reduced costs, or the reduced variability in annual catches that can come from reduced fishing rates, will show that a more restrictive policy would be in the long term interest of both countries.

4.3 Regular seasonal migrations

4.3.1 General requirements

This is the type of sharing for which coordination in setting management measures is most needed. Suppose two countries share a stock of this type, and biological, economic and social studies - possibly carried out in cooperation - show that a desirable level of fishing intensity would yield annual catches of 100 000 tons. If no further coordination is carried out, each country may well decide to take 60 000 tons or even more. The result would be that the target catch from the stock as a whole would be considerably exceeded,

and the stock would decline. Far from getting 60 000 tons each, the countries might be likely in the long run to get no more than 40 000 tons annually. Certainly any catch they did get would be taken at a much higher cost than necessary, or than that which would have occurred if the total fishing intensity had been kept at the target level.

Up to this point the problems of managing this type of shared stock are very similar to those of managing high seas fisheries under the old system of fully open access. The history of attempting to manage those fisheries do not give much encouragement, but there are some important differences. The most important is that access is limited to those countries in which the stock occurs; there will often be only two or three, and agreement between those countries cannot be disturbed by the entry of other countries into the fishery. Secondly, the characteristics of the stock relative to the EEZ of the different countries (e.g., the location of spawning or feeding area, etc.) provides some objective measures which can help reaching agreement on the allocation of shares in the fishery.

Assuming collaboration between the interested countries has advanced far enough to determine the state of the stock, the effect of fishing on it, and the biological effects of possible management actions, and analyses are also available (from individual or co-operative studies) of the social and economic effects of the actions, then the following steps are needed to manage the stocks:

(1) Choice of strategy; i.e., the determination of the preferred pattern of fishing (e.g., the level of the overall fishing intensity on the stock).

(2) Choice of tactics, i.e., the determination of the actions needed to achieve that pattern (e.g., the amount of catch to be taken, or the number of vessels allowed to operate in the forthcoming year).

(3) Implementation of the chosen action.

(4) Evaluation of the actions, including checks that the regulations are actually being implemented, and are having expected results.

4.3.2 The strategic choices

If the interests of the countries are reasonably similar - as will generally be the case for adjacent countries - this presents little difficulty. If the production of fish, regardless of cost, is a high priority, then a fishing strategy giving MSY, or a close approximation, will probably be chosen. If high catch rates and a good living for a few fishermen is a priority, then a low fishing intensity will be chosen. Difficulties will arise when countries have different objectives. For example, California and Mexico share a substantial anchovy stock. To Mexico this stock is potential raw material for a fish meal fishery, and a high rate of exploitation is desirable. To many in California the chief value of anchovy is as a food supply to valuable sport fishery, and - in limited quantities - as bait. For these, the optimum rate of exploitation is low. (There are those in California with the same interests as Mexico, but they are less numerous than the sports fishermen). Resolution of this type of conflict must be a matter of political negotiation.

4.3.3 Tactical decisions - Allocation

The key decision here is the allocation of benefits between the participants. There are in fact two separate operations - how big a share should each participant get, and how should the shares be measured. It is often tacitly assumed that shares should be expressed as so many tons out of a given Total Allowable Catch; this may be the best, as well as the obvious, choice but the choice should not be made without some thought. It can be difficult to set the correct catch limit to achieve the derived rate of exploitation when the population fluctuates from natural causes (and if the adjustment to fluctuation is not good enough the result can be to increase the amplitude of the fluctuation to the point where a downward fluctuation brings the stock to a point of collapse. This seems to have

happened to the pilchard stock off Namibia (Troadec et al., in press). It can also be difficult, if landings are dispersed along the coast, to check whether catch limits are being complied with. In purely national fisheries other measures of the impact of fishing on the stock, e.g., number of vessels, may be better. However, catch quotas have the great advantage that the units are clear - a division of a TAC of 100 000 tons into 50 000 tons for each country makes it clear that each country gets an equal share. The relative shares are much less clear if the agreement is that one country will operate 75 medium size trawlers, and the other allow 25 000 artisanal fishermen to work. The problems in the latter case will be increased still further when one country decides to up-grade the operating efficiency of the fishermen. What adjustment should be made to the number of units allowed to operate will be a fertile field of arguments.

These considerations were conclusive in most pre-EEZ international discussions, where (e.g., in ICNAF or NEAFC) allocations were (and still are, in the case of ICSEAF) expressed as a share of a TAC. For the present it is likely that agreements on managing shared stocks of this kind will continue to be expressed in terms of the weight caught, i.e., an overall TAC plus new agreement on how this TAC should be allocated to each country. However, consideration should be given to other approaches, e.g., expressing effort in terms of number of vessels.

Bases for allocation

The question here is how the allocation will be made. In the last resort this must be a matter of negotiations between the countries. The allocation of shares in particular stocks may be decided as part of negotiations on other stocks, or of wider negotiations on any other topics that the countries find convenient. Nevertheless decisions on allocations will clearly be easier to reach if there is some agreements in the general principles that should be taken into account.

In the open-access, pre-LOS era, the problem of allocation was discussed by the International Commission for the Northwest Atlantic Fisheries (ICNAF). From these discussions, which arose because it was recognized that without allocation of an overall quota, or TAC, most of the potential economics benefit from management would be dissipated, a set of general principles were developed. ICNAF's Standing Committee on Regulatory Measures recommended that "the shares of participating countries should be based mainly on historical performance (average catches over a datum period(s), with a small proportion of the total allowable catch set aside to provide for new entrants in the fishery, for non-member fishing countries, for member countries with developing fisheries, for coastal state preferences and for the fleets of member countries which were incapable of being diverted to other fisheries" (ICNAF, 1969).

These principles are now largely irrelevant. Past catches may be taken into account during some interim period of adjustment to the new regime of the sea, but it is doubtful if any country will agree that a neighbouring country should be entitled permanently to a larger proportion of catches from a shared stock merely because that country happened to develop its fishery earlier or faster. Permanent allocations will almost certainly have to be based on more basic features of the stock, and those that are more closely matched to the relation of the stock to the national EEZs. For example, if the stock spends nine months in one EEZ and three months in another, then, other things being equal, a reasonable allocation of the total TAC would seem to be 75% to the first country and 25% to the second.

In practice matters are more complicated. The effects of possible differences in the biological characteristics of the catches, e.g., one EEZ contains mostly small immature fish, are discussed in the following section; other complications that are discussed here are the contribution of biological events in one or other zone to the production of harvestable sizes of fish; the impact of the natural conditions in each zone on the costs of harvesting, and the general economic conditions in each country.

Fish are from several months up to several years old before they are harvested, and the success of the harvest depends on their having favourable conditions in these months or years, some of which may be spent a long way from the place where they are harvested. Allocations in the final harvest should therefore take account of the events from spawning onwards. This does not mean only looking at the position of the spawning and nursery grounds, and of the main feeding areas in relation to the various national EEZs, but also taking account of the impact that actions by the country concerned can have on the conditions for the stock of interest. Though the management of salmon stocks is not considered directly in this paper, these species do provide a good example of the principles that might with obvious modifications be applied to purely marine species. Successful spawning, and good survival during the early part of the salmon's life, depends on the country in whose rivers or streams the fish spawn maintaining good conditions by controlling the possible harmful effects of dam construction, logging, crop spraying, etc. One major reason why it is accepted that the coastal state concerned should have authority over salmon and other anadromous species is that without such acceptance the states concerned would have little or no interest in maintaining suitable conditions, and in due course there would be few if any salmon for anyone to catch.

Similar considerations can apply to purely marine species. A country is likely to expect a large allocation of a stock when the productivity of the stock is critically dependent on conditions in the EEZ of that country, especially when activities by the country can affect those conditions. For example, many offshore stocks have their nursery grounds in inshore areas - lagoons and estuaries, etc. - which can be seriously affected by land-reclamation, cutting of mangroves, etc. If a country controls these activities for the benefit of the fisheries it would expect a susbtantial allocation, regardless of the location of the fishing grounds, especially if these controls cause losses to other sectors of the national economy.

The factors that might be taken into consideration in setting allocations will include the position of the spawning areas, the nursery grounds, and the main feeding grounds of the adult fish, as well as the areas where the actual catches are taken. In addition it would be desirable to know how conditions in these areas affect the productivity of the stocks - its reproduction success, and the growth and mortality of the individuals. Information on most or all of these is poor or absent for many stocks, including the large majority of stocks off developing countries. This suggests that a large research effort will be needed if the allocation of shares in a common stock is to have a sound basis.

Allocation of shares also needs to take the practical and economic aspects into account. The presence of fish of a marketable size does not guarantee a successful fishery. Differences in behaviour of the fish at different stages in its annual migratory cycle will nearly always make them easier and cheaper to catch at certain times and places than at others. Many species are dispersed while feeding, but collect into compact, and easily caught, schools just before spawning. These spawning aggregations may occur in only one national EEZ, out of the number in which the stock occurs during the year. For example, the blue whiting in the northeast Atlantic is widely distributed during the feeding season from westward of the British Isles to the Faroes, Iceland and Norway, but the catch rates are high enough to be economically attractive only during the spawning season when it is restricted to British waters. The value of the individual fish on the market is also likely to vary during the year (and hence probably from one EEZ to another). Typically the fish is in best condition a little before spawning, drops rapidly during the spawning season to a minimum after spawning, and then gradually builds up during the feeding season.

Taking these factors together it is possible to consider the net worth of fish at any point in its annual migration cycle, as being the difference between its value in the market, and the costs of catching it. This is likely to be highly variable, and the total benefits from the stock are likely to be greatest when harvesting is concentrated at the times and places when the net worth is high.

There are other factors that are not biological, and not directly related to the characteristics of the stock, which will probably need to be taken into account in agreeing on allocation. Countries will differ in the value they set on being able to take a given share of the catch. Reasons for this include the existence of an efficient fleet that can take the catch at a low cost; a good marketing and distribution system, or a high demand for fish, so that a high price can be paid to fishermen; and a lack of other employment for those currently engaged in the fishery. These may not always be easy to express in comparable terms, e.g., a poor country, with few alternative supplies of protein, may set a high value on the right to fish even though, because of its poverty, the dollar value of the fish may be low. Nevertheless, with the reservations, it would seem that the overall benefits from the resource would be greatest if the countries which place a greater "value" on a share do have a larger allocation.

These economic considerations indicate the directions in which the allocations can be made, but do not give quantitative guidance on the magnitude of the allocations, e.g., they do not indicate whether a major share should be 55% or 90% of the total. Some limits on the magnitudes of the shares may be obtained from a consideration of the likely course of events if there is no agreement on allocation. Boundaries to the possible allocation will be given by the benefits that each country would obtain in the absence of agreement on allocation. The likely course of events in the case of an unallocated quota applied to a national fishery has been often described in the economic literature (e.g., Crutchfield and Zellner, 1962). The main events - a scramble by all fishermen to maximize their catches while fishing is permitted, and a resulting rapid rise in the costs of fishery until the situation is reached, at which the individual fisherman can no longer afford to try to increase his share - would undoubtedly be repeated in the multi-country situation. Costs will increase as countries seek to maintain or increase their share of the total until some equilibrium is reached, with the more efficient countries (or those prepared to provide their fishermen with the greatest subsidies) getting the largest shares - perhaps even to the point when the less efficient are driven out of the fishery altogether - but at a high cost. Estimates might be made of the shares that would be taken by each country in this equilibrium position, and these could then be used as a first approximation to the allocations. More detailed examination of the economic aspects of the management strategies that could be adopted in this situation have been made (e.g., Munro, 1979) but are outside the scope of the present paper.

4.3.4 Implementation and enforcement

Without adequate implementation and enforcement the best agreements on the strategy of management and allocation of the benefits can be useless. Enforcement of agreed regulations has always been a difficult problem in international fisheries, and it is one that in respect of the type of shared stock discussed in this section, may be made harder by the new regime of the sea. Fishermen always suspect that while their compliance with regulations may be being enforced, other groups of fishermen - from a different country, or from a different port in the same country - are less adequately controlled. This makes them less willing to comply with the regulations, and without the acceptance of the fishermen, enforcement can be very difficult. It is therefore essential in any multi-national fishery that fishermen (and administrators and others) in one country can be assured that the fishermen of other countries are complying with the regulations. Under the old regime of the sea, when most fishing was done on the high seas, there were a number of arrangements, e.g., the International Inspection Schemes of ICNAF and NEAFC, under which authorized inspectors of one country could stop fishing vessels of another country participating in the scheme. While legal action in respect of any apparent infraction remained the prerogative of the flag state, the arrangement did allow each country to know what extent fishermen of other countries were complying with the regulations.

The continuation of this scheme under the new regime would imply, if it were to be effective, that inspection vessels of one country would be able to stop and inspect vessels of a second country while in the second country's EEZ - a practice which is unlikely to be generally acceptable. Some scheme, however, is necessary to provide the necessary

reassurance to each country that the others are applying the agreed measures. Agreeing on an appropriate scheme may not be easy, but is not impossible; for example, the international inspection scheme of the International Whaling Commission includes arrangements for inspectors from one country to be present at land stations of other countries. The point is that the task of such international inspectors is not to initiate legal proceedings (which would be unacceptable) but only to establish facts.

The actual arrangements reached in any particular case would be the result of negotiations between the countries immediately concerned, and would take account of many factors outside fisheries, particularly the general degree of collaboration between the countries. They will not be discussed further here; what is worth noting here is that the various regulations do not involve equal difficulties in checking that they are being followed. In particular it is worth re-examining the question whether the magnitude of the catch is necessarily a better measure of the amount of fishing than measures such as the number or size of the fishing vessels. Experience of catch quotas in national and international fisheries has shown that the difficulties of enforcement increase rapidly as the number of landing places (and also the unit value of the fish) increase, often to the point that adequate enforcement is impracticable. Even in the North Sea, surrounded by countries with good administrative structures, enforcement of quotas is far from perfect. For example, it is believed that the catches of soles from the North Sea in some recent years was 50% or more above the reported total (ICES, 1980, Table 63). The danger of this situation is that not only are the regulations ineffective but once the statistics become unreliable it is very difficult to know what is happening to the fisheries and the fish stocks, and hence to plan more effective regulations.

The statistics of the fisheries of most developing countries is at the moment far from satisfactory; improvement may not come readily if it were felt that one result of such improvement would be that its fishermen might be more rigorously controlled than those of neighbouring countries fishing the same stock. Even if there are improvements, it would still be difficult for one country to satisfy itself that the catches of other countries were in fact being kept to the agreed level. Consideration should therefore be given to other measures of the amount of fishing - e.g., numbers of ships - that can be more easily verified.

4.4 Movements related to growth and development

These present some of the most difficult problems in the management of shared stocks. Both practical experience and theoretical studies have showed that the benefits from harvesting a resource are increased if the capture of certain sizes or condition of fish (particularly small fish) is avoided, and fishing is concentrated around some optimum size of capture. Almost by definition catches in national EEZs will differ in the sizes and condition of fish, and it can easily happen that there would be considerable advantages, in terms of the total weight caught, if fishing were concentrated in one or other area.

In this situation, it is difficult to see, unless other factors are brought to bear, what actions can be taken. It is not in the interests of the state in whose waters the small (or otherwise "undesirable" fish) are taken to reduce its catches for the benefits of the other state (or states) even if such action might add to the catch of all states taken together. Certainly the draft text for the new Law of the Sea, while calling, e.g., in Article 63, for consultation and collaboration between states, does not call for self-sacrificing action of this type for the sake of conservation or better management. However, since the benefits to one country exceed the sacrifices made by the other (otherwise the total would not be increased) there are clearly opportunities for the beneficiary country to offer trade-offs in some other negotiations (not necessarily connected with fisheries). A country may well be able to discourage any further expansion of a national fishery on small fish in return for concessions in other matters, though it may be much more difficult, especially politically, to take action to reduce any national fishery. The real answer to better management of this type of fishery may however lie in the country in which

the large fish occur allowing access by the other country to its EEZ.

4.5 Fishing in other EEZs

Considerable discussions have taken place over access to national EEZs by foreign vessels. These have almost wholly concerned access to the part of the potential harvest - the 'surplus' - not taken by the coastal state, by states which have no special interest in the stock. The possible harvesting of a shared stock by fishermen of one state in the EEZ of an adjacent state has been much more rarely discussed.

In the case of stocks making seasonal migrations for which agreement has been reached between two countries on the allocation of the total catch, it makes little difference to country A whether country B takes its share of the total catch in its own EEZ, or that of A. It can, however, make a big difference to country B, and the economic success of its fishery if its allocation can be taken in either EEZ. In many cases this may allow a fishery that is normally highly seasonal to extend its operation to most of the year. A fairly extreme example is the Gambia, whose EEZ is a narrow strip, across which large stocks of sardinella (and other species) migrate. The fish occur in Gambian waters in sufficient numbers and concentrations to support an industrial fishery only for short and irregular periods, but at other times occur in Senegalese and other waters. During these periods total catches can be high (equivalent to a good-sized industrial fishery for Gambia), but a Gambian industrial fishery is only viable if it has access to the shared stock when it is in Senegalese or other waters.

The benefits are even greater in the case of the other type, a 'development' migration. If, for example, the country in which the nursery grounds occur is allowed to fish on the adult fish when they are in the EEZ of another country, this ability also gives it the incentive to reduce fishing on the small fish.

The distinction between access by a non-coastal state to a "surplus", and the transfer by a coastal state of the location of its activities on a shared stock from one EEZ to another should now be clear. In the first case the state whose fishermen are granted access has no authority or jurisdiction over the stock; in the second, it does have such jurisdiction to the extent that the stock does occur in its own EEZ. In the latter case decisions on the pattern of fishing by each of the countries sharing the stocks can be made in two stages. First is the decision on the magnitude of the shares to be taken by each country (e.g., the allocation of shares in some Total Allowable Catch); this will be done largely on the basis of the distribution of the stock relative to the national EEZs. Second, there can be agreements on the extent to which one country can take its allocation in the EEZ of another. For example, the USSR has a large share of the TAC of Arctic-Norwegian cod because much of the feeding grounds for young cod, and the most productive fishing grounds for small fish, occur in the Soviet EEZ. However, it would probably be to the advantage of Norway, in whose EEZ the spawning area, and most of the best fishing grounds for large cod occur, if much of the Soviet allocation were taken in the Norwegian EEZ, i.e., as large cod rather than small.

Apart from increasing economic efficiency, and possibly also making the pattern of fishing better adapted to the rational utilization of the stock, access to the EEZs of adjacent countries could have one other beneficial effect. Especially if there is mutual access, this pattern of fishing could lead to a better mutual trust that the agreements on management actions (limits on catches or numbers of boats) are in fact being followed.

4.6 Administrative arrangements

Management of shared migratory stocks will require formal and binding agreements between countries on the measures to be implemented. Unlike the case of non-migratory, transboundary, stocks where, if each country adopts measures suited to its own national interest all will be well (or reasonably so), similar selfish procedures in the case of

these stocks will lead to competition to maximize national shares, and the same disasters of over-fishing that have always occurred with open access.

Two types of arrangements are possible. In one a permanent Commission is established whose recommendations are binding on member countries (subject usually to some "objection" procedure). In the other agreements are made directly between governments, possibly on an ad hoc basis for each year. In practice a hybrid procedure has sometimes been followed. For example, the management of yellowfin tuna in the eastern Pacific is based on the analyses of the Inter-American Tropical Tuna Commission (I-ATTC). After these have been discussed in the Commission, and suggested levels of total catch reviewed, further inter-governmental discussions outside the framework of the Commission are held to examine the actual detailed regulations (e.g., exemptions for small vessels, or countries with small fleets). Only after agreement on detailed measures have been reached at these outside meetings is the Commission meeting resumed to agree formally on the overall quota. A somewhat similar procedure was followed for some time in respect of Antarctic whales. The critical discussions on how to allocate the quota between countries were held outside the framework of the International Whaling Commission.

It may be that somewhat similar procedures will often be found useful in respect of shared stocks. Many of these stocks are shared between only a limited number of countries. The most frequent situation is probably for only two adjacent countries to share a stock whose distribution lies across the boundary between their EEZs. In the post-UNCLOS era it is unlikely that these countries will want others to be involved in discussions on management of their stocks. The membership of regional fishery bodies, and even of the sub-committees, or other sub-regional groupings of these bodies, matches in only very few cases the group of countries that share any one particular stock, usually being larger. At the same time the meetings of these bodies provide both a forum in which the problems of managing the stocks in the region can be discussed in general terms, and an occasion at which group of countries can meet together to agree on specific measures. That is, regional bodies may become both less formally involved in management (because the formal decision will be taken by ad hoc meetings between the countries directly concerned), and more influential in practice (because their meetings will be the occasions for reaching more effective management decisions than could ever be reached in the pre-EEZ open-acess situation).

4.7 High seas fisheries

The changes in the legal regime of the sea do not, on the face of it, alter greatly the conditions under which the fisheries beyond 200 miles are carried out. Appropriate sections in the draft text call upon the countries concerned to collaborate with a view to achieving rational management, but the formal effect is not much more than the expression of a hope.

The real impact of the legal changes is, however, for most stocks quite substantial. Most of the stocks concerned - nearly all of which are tuna - are also harvested within 200 miles. These operations will come under the control of the coastal state or states, and where these catches are a high proportion of the total, the coastal states may be in a position to bring about a management regime that is not very different from one or other of the situations described earlier in this section. A fairly extreme example is provided by the island states in the southwest Pacific. The regional geography is such that the EEZs of the various states form a close-knit mosaic with the area of high seas outside any EEZ being extremely small. It is certainly too small for any catching of skipjack or other tunas (the main resource of the region) to be practicable without access to some at least of the national EEZs. The coastal states, particularly if they coordinate their negotiations with non-local fishing fleets, can put themselves in a position to ensure that among the conditions of access is an agreement to abide with regional management arrangements also when fishing on the high seas. The South Pacific presents another unusual feature in that many of the newly emerging island states are not in a position to engage directly in large-scale tuna fishing, and for the foreseeable future much of the fishing will continue

to be carried out by vessels based outside the region. The complexities of the arrangements that are emerging in this region can only be touched on here. The main point is that the new regime of the sea, plus the accidents of local geography, has transferred the tuna stocks in that region into a resource that can potentially be controlled by the coastal states, and the problems are largely similar to those of other migrating stocks shared by several countries (though pending the full analysis of the tagging experiments carried out by the South Pacific Commission, the exact nature of the sharing is not very well established).

A more typical situation for tuna is provided by the yellowfin tuna in the eastern tropical Pacific. This can be fished in quantity both inside and outside 200 miles off central America from Mexico to Ecuador. The inability to fish inside 200 miles would lower the efficiency and profitableness of a non-local fishery, but not make it completely impracticable. In this situation most of the problems that inhibited effective management in the pre-EEZ era - the need for management measures to be reached by consensus, and the ability of states outside the agreement to enter the fishery and reap most of the benefits from the agreement - still remain. While considerable thought has gone into the examination of how tuna can be managed (e.g., Joseph and Greenough, 1979; King, 1979), it is far from clear how effective management can be achieved. The nature of the population dynamics of tuna (so far as they are currently known) make the failure to manage tuna both more likely, and less dangerous. Unlike some other groups of fish (noticeably herrings and their allies) tuna (except possibly bluefin tuna) seem to be resilient under heavy exploitation, with the gross production being maintained. In the absence of effective management the industry may have economic difficulties, but the tuna fisheries have not collapsed. On the other hand, like the prospect of being hanged, the collapse of a fishery does concentrate the mind wonderfully. The history of whaling and of other fisheries show clearly that it often takes the collapse of the fishery to bring into force effective management measures. Lacking such measures for action it may be some time before a strict management regime for tuna is set up. In any case it is not possible here to go further into the problem of tuna management.

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M-43
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